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**THE EFFECT OF A SYNTHETIC LUBRICANT AND TWO DIBASIC ACID ESTERS
ON CERTAIN USAF FABRICS**

CLARENCE D. SMITH, 1ST LT, USAF

MATERIALS LABORATORY

MARCH 1954

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Approved for Public Release

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Clarence D. Smith, 1st Lt, USAF

Materials Laboratory

March 1954

RDO No. 612-13

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

This report was prepared by the Textiles Branch and was initiated under Research and Development Order No. 612-13, "Textile Materials for Air Force Clothing". The report was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Lt C. D. Smith acting as project engineer.

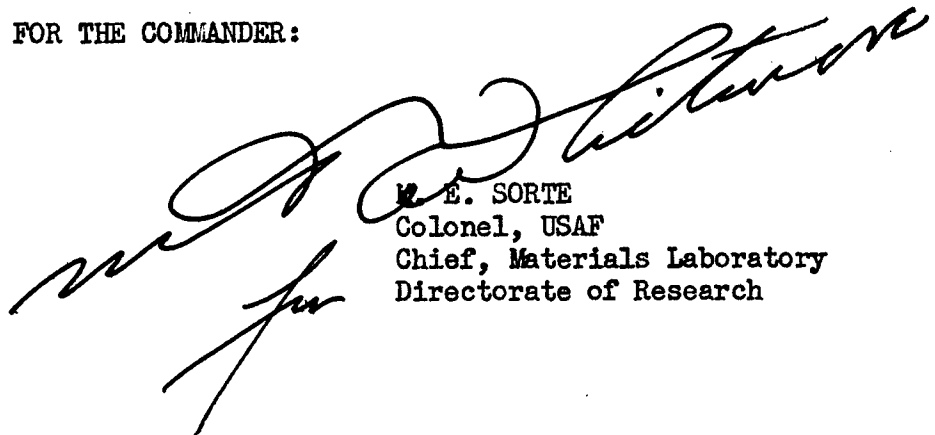
ABSTRACT

This investigation was initiated to determine if fabrics employed by the USAF were subject to degradation or deterioration when exposed to the lubricating oil covered by Specification MIL-L-7808 and the acid esters, di-2-ethyl hexyl adipate and di-2-ethyl hexyl sebacate. Need for an investigation was realized upon receipt of information that fabrics had been damaged when exposed to synthetic lubricants. In order to accomplish the desired program a series of fabrics composed of fibers that are commonly used in USAF fabrics was exposed to the above synthetic lubricants at room temperature and at 160°F. After exposure, laundering and dry cleaning tests were conducted to determine their effect in conjunction with the lubricants. By diaphragm burst tests it was found that no damage was apparent in the fabrics used when exposed to the above synthetic lubricants.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



E. E. SORTE
Colonel, USAF
Chief, Materials Laboratory
Directorate of Research

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THE EFFECT OF A SYNTHETIC LUBRICANT AND TWO DIBASIC ACID ESTERS ON CERTAIN USAF FABRICS

I. INTRODUCTION

Information has been received that fabric exposed to Lubricating Oil, Gas Turbine, Aircraft, Specification MIL-L-7808 has deteriorated. The oil is a synthetic lubricant usually composed principally of a sebacic acid ester. Because the Air Force plans increased use of synthetic lubricants of this type, an investigation of the degradation or deterioration of fabrics caused by synthetic lubricants was initiated. The investigation was planned to include Air Force functional fabrics which contained fibers of any nature that could be exposed during normal use to the lubricants under investigation.

It was considered desirable to conduct tests that would provide information on damage caused by MIL-L-7808 and would also give an indication of damage which might be caused by other synthetic lubricants in use by the Air Force. It was thought that by using di-2-ethyl hexyl adipate and di-2-ethyl hexyl sebacate (these are basic constituents of many Air Force synthetic lubricants) in addition to the oil covered by Specification MIL-L-7808 the desired information could be obtained. By using the above materials the results obtained in tests using the lubricant itself could be compared with results obtained when using its basic constituent (oil covered by MIL-L-7808 is principally di-2-ethyl hexyl sebacate) and, theoretically, the damage caused by lubricants composed principally of the same material could be estimated. Depending on the results obtained in comparing these two materials, conclusions could possibly be drawn from tests employing the di-2-ethyl hexyl adipate in relation to the synthetic lubricants of which it is a principal constituent. Basically, this was why the specific lubricants were chosen for this study.

II. SELECTION OF FABRICS

It was evident that tests on all the different Air Force fabrics would be too lengthy and confusing to be readily useful. It was considered more practical and just as conclusive to test a series of fabrics that would give an indication of the damage to the different fibers that are used in Air Force fabrics. The following fabrics were selected for testing:

1. 100% cotton - 4 oz. 2x2 basket weave
2. 100% wool - Shade 193 - MIL-C-4485
3. 100% nylon - MIL-C-7020
4. 100% rayon - For experimental cargo parachutes
5. 100% Dacron - For experimental parachutes - Fabric made in accordance with MIL-C-7020.
6. 100% Orlon - Experimental fabric for wing covers.
7. Nylon-viscose - MIL-C-4072 - Has nylon warp and viscose rayon filling and is used in Air Force raincoats.

By determining damage to the above fabrics it was thought that it would be possible to predict damage to fabrics composed of blends of the fibers that were represented in the fabrics tested. For example, if the fabric composed of fiber "X" showed damage and the fabric composed of fiber "Y" showed no damage, then a fabric composed of a blend of fibers "X" and "Y" should show damage depending on the amount of fiber "X" used in the blends. Other variable factors such as temperature, type of oil, and length of exposure could also affect degradation.

III. TREATMENTS OF FABRICS

It was necessary to decide what treatment was to be given the test fabrics and what test method was to be used for evaluation. It was evident that the fabrics should be exposed at room temperature and at elevated temperatures and it was considered advisable to determine the effect of dry cleaning and laundering along with exposure because it was probable that Air Force items would be subjected to these treatments.

A complete schedule of treatments was outlined for each fabric as follows:

A. Treatments of fabrics with lubricants at room temperature.

1. Original fabric - no treatment given.
2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours.
3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours.
4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours.

B. Treatments of fabrics with lubricants at elevated temperature.

1. Fabric subjected to 160°F for 72 hours - no other treatment.
2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72 hours.
3. Fabric soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours.
4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours.

C. Treatments of fabrics with lubricants at room temperature and dry cleaning.

1. Fabric dry cleaned - no other treatment.

2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours then dry cleaned.
 3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours then dry cleaned.
 4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours then dry cleaned.
- D. Treatments of fabrics with lubricants at elevated temperature and dry cleaning.
1. Fabric subjected to 160°F for 72 hours then dry cleaned.
 2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72 hours then dry cleaned.
 3. Fabrics soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours then dry cleaned.
 4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours then dry cleaned.
- E. Treatments of fabrics with lubricants at room temperature and laundering.
1. Fabric laundered - no other treatment.
 2. Fabric soaked in di-2-ethyl hexyl adipate at room temperature for 72 hours then laundered.
 3. Fabric soaked in di-2-ethyl hexyl sebacate at room temperature for 72 hours then laundered.
 4. Fabric soaked in MIL-L-7808 lubricant at room temperature for 72 hours then laundered.
- F. Treatments of fabrics with lubricants at elevated temperature and laundering.
1. Fabric subjected to 160°F for 72 hours then laundered.
 2. Fabric soaked in di-2-ethyl hexyl adipate at 160°F for 72

hours then laundered.

3. Fabric soaked in di-2-ethyl hexyl sebacate at 160°F for 72 hours then laundered.

4. Fabric soaked in MIL-L-7808 lubricant at 160°F for 72 hours then laundered.

The fabrics were brought to standard conditions, 70°F and 65% relative humidity, by conditioning for 24 hours, after each treatment, and then evaluation tests were conducted.

Dry cleaning of the fabrics was conducted as described in method 5610, Federal Specification CCC-T-191b. Dry cleaning solvent conformed to the requirements of Federal Specification P-S-661. Each dry cleaning was conducted using five samples of fabric, 4 inches by 4 inches each, and 350 milliliters of solvent per jar. The Launder-Ometer was run for 25 minutes at a temperature of 85°F, after which the samples were extracted in a centrifugal extractor, air dried, and conditioned.

The laundering was also conducted in the Launder-Ometer and was conducted with five samples, 4 inches by 4 inches each, contained in each jar. Laundering was done by using 350 milliliters of 0.5 percent soap solution per jar. The treatment was run for 30 minutes at 100°F, after which the samples were rinsed thoroughly at 100°F, extracted in a centrifugal extractor, air dried, and conditioned.

IV. TEST AND EVALUATION

The test chosen for evaluation of the effect of the various treatments was, "Strength of Cloth; diaphragm bursting method", number 5122, Federal Specification CCC-T-191b. This test was originally designed for testing of paper but since has been adapted to fabrics and is a good means for rapid evaluation, although it does not provide accuracy to the degree that a ravel strip test does.

Due to the mechanism of bursting fabrics in a diaphragm device, the fabric direction having the lower elongation will normally be the first to fail. Hence, in testing the nylon-viscose rayon fabric the filling (rayon) direction consistently was the first to fail. In effect then, the tests on this cloth primarily determined the resistance of the direct spun viscose rayon to degradation by the various treatments, without respect to effects on the nylon.

Five samples of each fabric were treated in each of the twenty-four treatments previously outlined. Results of tests on these samples have been tabulated in Tables 1, 2, 3, 4, 5, and 6. Each table must be considered separately in evaluation of degradation because each table contains test results of an original or a treated control fabric along with results of tests of fabrics that had been given the same treatments as the control and in addition had been exposed to the lubricants under controlled conditions. For example, in Table 4, the samples that were exposed to 160°F for 72 hours then dry cleaned must be considered control samples because similar samples were soaked in the lubricants under the same conditions and were given the same dry cleaning afterwards.

Upon examination of the test results, variations in bursting strength were found but these variations were small enough that they may be considered either test error or normal differences in fabrics. These results presented conclusive evidence that there was no damage to any of the fabrics as a result of exposure to any of the three lubricants that was drastic enough to cause concern.

As a result of this investigation, it is believed that the degradation of

fabrics reported to have been caused by synthetic lubricants must have been caused by either different chemicals or different conditions than the ones used in this investigation.

Table 1

Strengths of Fabrics Treated with Lubricants at Room Temperature

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Original fabric no treatment given	155 165 175 165 <u>160</u> <u>164</u>	145 135 140 140 <u>135</u> <u>139</u>	175 170 170 160 <u>170</u> <u>169</u>	170 180 175 180 <u>170</u> <u>175</u>	265 265 260 255 <u>265</u> <u>262</u>	245 235 235 230 <u>230</u> <u>235</u>	270 295 295 320 <u>320</u> <u>300</u>
Average							
Fabric soaked in di-2-ethyl hexyl adipate room temperature, 72 hours	155 180 170 165 <u>145</u> <u>163</u>	140 135 145 140 <u>140</u> <u>140</u>	160 170 175 170 <u>165</u> <u>168</u>	165 165 175 170 <u>170</u> <u>169</u>	255 260 255 255 <u>255</u> <u>256</u>	245 260 265 265 <u>260</u> <u>259</u>	305 290 300 305 <u>280</u> <u>296</u>
Average							
Fabric soaked in di-2-ethyl hexyl sebacate room temperature, 72 hours	155 165 140 150 160 <u>154</u>	140 145 135 140 <u>140</u> <u>140</u>	165 160 160 160 <u>160</u> <u>161</u>	160 170 170 165 <u>170</u> <u>167</u>	260 255 250 255 <u>260</u> <u>256</u>	255 265 260 265 <u>260</u> <u>261</u>	300 305 305 305 <u>300</u> <u>303</u>
Average							
Fabric soaked in MIL-L-7808 lubricant room temperature, 72 hours	165 160 165 165 <u>145</u> <u>160</u>	135 140 140 135 <u>135</u> <u>137</u>	165 165 160 165 <u>165</u> <u>164</u>	175 175 170 165 <u>165</u> <u>170</u>	255 255 255 260 <u>255</u> <u>256</u>	275 275 270 250 <u>240</u> <u>262</u>	295 310 305 315 <u>305</u> <u>306</u>
Average							

Note: Results reported are Mullen Burst Points

Table 2
Strengths of Fabrics Treated with Lubricants at Elevated Temperature

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric subjected to 160° F. 72 hours	160	140	165	190	255	245	295
No other treatment	165	140	165	175	255	260	300
	160	135	165	170	255	260	295
	150	135	160	180	255	255	300
Average	<u>175</u>	<u>135</u>	<u>165</u>	<u>175</u>	<u>250</u>	<u>250</u>	<u>295</u>
	<u>162</u>	<u>137</u>	<u>164</u>	<u>178</u>	<u>254</u>	<u>254</u>	<u>297</u>
Fabric soaked in di-2-ethyl hexyl adipate	150	135	165	165	260	245	290
160° F. - 72 hours	165	140	165	160	260	255	300
	150	140	160	180	255	255	285
	165	140	160	165	250	255	300
Average	<u>165</u>	<u>145</u>	<u>160</u>	<u>165</u>	<u>260</u>	<u>260</u>	<u>300</u>
	<u>159</u>	<u>140</u>	<u>162</u>	<u>167</u>	<u>257</u>	<u>254</u>	<u>295</u>
Fabric soaked in di-2-ethyl hexyl sebacate	150	140	165	170	265	260	290
160° F. - 72 hours	155	135	160	170	255	260	295
	165	140	160	170	250	240	290
	145	140	160	165	250	255	280
Average	<u>155</u>	<u>140</u>	<u>155</u>	<u>170</u>	<u>255</u>	<u>260</u>	<u>270</u>
	<u>154</u>	<u>139</u>	<u>160</u>	<u>169</u>	<u>255</u>	<u>255</u>	<u>285</u>
Fabric soaked in MIL-L-7808 lubricant	170	140	165	165	255	260	290
160° F. - 72 hours	160	140	160	180	250	260	300
	170	135	160	175	255	260	310
	165	140	165	170	250	265	300
Average	<u>170</u>	<u>140</u>	<u>160</u>	<u>165</u>	<u>250</u>	<u>260</u>	<u>295</u>
	<u>167</u>	<u>139</u>	<u>162</u>	<u>171</u>	<u>252</u>	<u>261</u>	<u>299</u>

Note: Results reported are Mullen Burst Points

Table 3

Strengths of Fabrics Treated with Lubricants at Room Temperature
and Dry Cleaning

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon- Viscose
Fabric dry cleaned	165	140	165	190	255	270	300
No other treatment	160	135	160	180	260	260	295
	165	135	170	180	260	260	310
	160	140	170	180	255	270	295
Average	<u>170</u>	<u>140</u>	<u>165</u>	<u>170</u>	<u>255</u>	<u>250</u>	<u>305</u>
	<u>165</u>	<u>138</u>	<u>166</u>	<u>180</u>	<u>257</u>	<u>262</u>	<u>301</u>
Fabric soaked in di-2-ethyl hexyl adipate	150	140	160	170	250	260	300
room temperature, 72 hours	165	140	165	175	250	275	310
dry cleaned	160	140	165	165	255	255	305
	160	145	160	170	250	255	310
Average	<u>160</u>	<u>135</u>	<u>165</u>	<u>165</u>	<u>255</u>	<u>265</u>	<u>310</u>
	<u>159</u>	<u>140</u>	<u>163</u>	<u>169</u>	<u>252</u>	<u>262</u>	<u>307</u>
Fabric soaked in di-2-ethyl hexyl sebacate	170	135	170	175	255	265	300
room temperature, 72 hours	150	140	160	165	260	270	290
dry cleaned	155	135	155	160	260	260	305
	155	140	160	155	255	260	310
Average	<u>165</u>	<u>140</u>	<u>160</u>	<u>170</u>	<u>260</u>	<u>240</u>	<u>300</u>
	<u>159</u>	<u>138</u>	<u>161</u>	<u>165</u>	<u>258</u>	<u>259</u>	<u>301</u>
Fabric soaked in MIL-L- 7808 lubricant	170	135	155	170	260	280	300
Room temperature, 72 hours	160	135	160	165	250	285	305
dry cleaned	170	135	160	185	250	260	295
	160	135	165	175	255	280	280
Average	<u>165</u>	<u>135</u>	<u>165</u>	<u>180</u>	<u>260</u>	<u>275</u>	<u>295</u>
	<u>165</u>	<u>135</u>	<u>161</u>	<u>175</u>	<u>255</u>	<u>276</u>	<u>295</u>

Note: Results reported are Mullen Burst Points

Table 4
Strengths of Fabrics Treated with Lubricants at Elevated Temperatures and Dry Cleaning

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric subjected to 160° F. 72 hours, dry cleaned	155 160 155 160 165 159	135 140 135 140 135 137	165 165 165 160 160 163	175 170 170 175 175 173	250 250 255 255 255 253	260 240 250 240 245 247	315 310 300 305 310 308
Average							
Fabric soaked in di-2-ethyl hexyl adipate 160° F. - 72 hours dry cleaned	155 145 150 155 155 152	140 140 135 135 140 138	160 155 155 160 165 159	145 140 145 135 145 142	255 255 255 255 250 254	260 260 260 260 255 259	290 305 305 300 300 300
Average							
Fabric soaked in di-2-ethyl hexyl sebacate 160° F. - 72 hours dry cleaned	140 155 160 160 150 153	135 135 135 135 140 136	160 160 160 160 160 160	160 175 165 160 160 164	255 250 255 255 250 253	255 265 265 270 255 262	315 315 305 310 300 309
Average							
Fabric soaked in MIL-L-7808 lubricant 160° F. - 72 hours dry cleaned	155 160 165 160 140 156	145 140 135 140 140 140	160 160 160 160 160 160	165 160 170 170 155 161	250 250 250 250 245 249	265 265 275 270 240 263	315 295 300 300 310 304
Average							

Note: Results reported are Mullen Burst Points

Table 5
Strengths of Fabrics Treated with Lubricants at Room Temperature and Laundering

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric laundered no other treatment	160 145 140 140 140 145	130 125 120 125 125 125	165 155 165 165 165 163	190 185 180 180 185 184	255 250 255 255 260 255	265 280 275 275 270 273	290 295 290 290 300 293
Average							
Fabric soaked in di-2-ethyl hexyl adipate room temperature, 72 hours laundered	140 145 135 140 150 142	130 130 135 135 135 133	160 165 160 160 165 162	190 180 195 190 175 186	255 255 255 255 255 255	260 250 250 265 240 253	300 305 300 295 300 300
Average							
Fabric soaked in di-2-ethyl hexyl sebacate room temperature, 72 hours laundered	160 140 150 145 150 149	130 135 135 135 130 133	160 165 170 160 160 163	190 195 185 170 185 185	250 250 250 250 255 251	265 260 240 260 255 256	285 280 310 295 300 294
Average							
Fabric soaked in MIL-L-7808 lubricant room temperature, 72 hours laundered	135 145 145 125 140 138	125 125 125 125 125 125	160 160 160 160 155 159	190 170 170 165 155 170	250 255 250 245 250 250	235 260 255 260 235 249	280 285 285 315 285 290
Average							

Note: Results reported are Mullen Burst Points

Strengths of Fabrics Treated with Lubricants at Elevated Temperature and Laundering

Table 6

	Cotton	Wool	Nylon	Rayon	Dacron	Orlon	Nylon-Viscose
Fabric subjected to 160° F. 72 hours, laundered	160 145 150 150 140 149	130 130 125 125 130 128	160 160 165 165 160 162	200 195 190 180 185 190	250 250 255 250 255 252	265 270 245 270 270 264	295 300 280 290 280 289
Average							
Fabric soaked in di-2-ethyl hexyl adipate 160° F. - 72 hours laundered	155 160 165 155 150 157	125 125 130 130 130 128	165 165 165 165 165 165	175 165 165 155 165 165	255 255 250 255 255 254	230 260 260 250 255 251	295 295 285 285 295 291
Average							
Fabric soaked in di-2-ethyl hexyl sebacate 160° F. - 72 hours laundered	150 135 160 160 155 152	125 130 125 125 125 126	155 160 160 160 160 159	160 175 165 170 175 169	250 235 250 250 250 247	260 240 260 270 260 258	270 275 270 280 270 273
Average							
Fabric soaked in MIL-L-7808 lubricant 160° F. - 72 hours laundered	155 145 155 140 145 148	125 125 130 125 130 127	155 160 160 160 160 159	185 185 185 175 185 183	250 250 250 250 250 250	235 260 255 260 255 253	305 285 295 295 290 294
Average							

Note: Results reported are Mullen Burst Points